

A **buffer solution** helps to maintain a constant pH, it is composed of a weak acid (or base) + its conjugate base (or acid) in equal quantities.

If a buffer solution is diluted the pH is not affected as the $\frac{[\text{acid}]}{[\text{base}]}$ ratio remains same.

$\text{H}^+_{(\text{aq})} + \text{HCO}_3^-_{(\text{aq})} \rightleftharpoons \text{H}_2\text{CO}_{3(\text{aq})}$ **buffer zone** the pH range ($\text{pK}_a \pm 1$) of which the buffer solution is effective



Calculate the pH of a buffer solution when 70ml of 0.15 mol L^{-1} of NaCH_3COO is added to 30ml of 0.15 mol L^{-1} CH_3COOH
 $K_a(\text{CH}_3\text{COOH}) = 1.74 \times 10^{-5}$

$$\frac{70}{100} \times 0.15 = [\text{CH}_3\text{COO}^-] \quad \frac{30}{100} \times 0.15 = [\text{CH}_3\text{COOH}]$$

$$0.105$$

$$0.045$$

$$K_a = \frac{[\text{H}_3\text{O}^+][0.105]}{0.045} = 1.74 \times 10^{-5}$$

$$[\text{H}_3\text{O}^+] = \frac{(1.74 \times 10^{-5})(0.045)}{(0.105)} = 7.46 \times 10^{-6}$$

$$\text{pH} = -\log(7.46 \times 10^{-6}) = 5.13 = \text{ANS}$$

buffer calculations



$$K_a = \frac{[\text{H}_3\text{O}^+][\text{A}^-]}{[\text{HA}]}$$

$$[\text{HA}]$$

in a buffer concs are equal

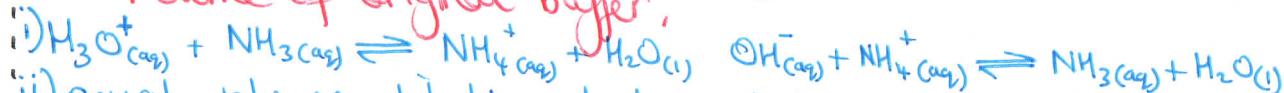
$$K_a = [\text{H}_3\text{O}^+]$$

$$\text{pK}_a = \text{pH}$$

because $\text{pH} = -\log[\text{H}_3\text{O}^+]$
 $\text{pK}_a = -\log K_a$

Equal volumes of 0.2 M aqueous solutions of ammonium chloride and ammonia are combined to form a buffer solution $M(\text{NH}_4\text{Cl}) = 53.5 \text{ g/mol}$.

- write the equations if small amount acid or base added
- calculate the pH of the buffer soln $K_a(\text{NH}_4^+) = 5.75 \times 10^{-10}$
- calculate the pH if 2ml of 1 M HCl added to 1 litre of buffer
- calculate pH of new buffer if 5 g NH_4Cl dissolved in 1 litre of original buffer.



ii) equal volumes, dilution factor of 2 $[\text{NH}_3] = [\text{NH}_4^+] = 0.1 \text{ M}$
 $\text{pH} = \text{pK}_a = -\log K_a = -\log [\text{H}_3\text{O}^+] = -\log(5.75 \times 10^{-10}) = 9.24$
 $K_a = \frac{[\text{H}_3\text{O}^+][\text{A}^-]}{[\text{HA}]}$

iii) $n(\text{HCl}) = C \times V = 1 \times 0.002 = 0.002 \text{ moles}$

This was added to buffer + reacts with NH_3 to form NH_4^+

$$\text{new } [\text{NH}_3] = 0.1 - 0.002 = 0.098$$

$$\text{new } [\text{NH}_4^+] = 0.1 + 0.002 = 0.102$$

$$\text{pH} = \text{pK}_a + \log \frac{0.098}{0.102} = 9.24 - 0.017 = 9.22$$

from pH above

iv) $n(\text{NH}_4^+)_{\text{added}} = n(\text{NH}_4\text{Cl})_{\text{added}}$
 $= \frac{5 \text{ g}}{53.5 \text{ g/mol}} = 0.093 \text{ moles added to 1 litre}$

$[\text{NH}_3]$ still $\sim 0.1 \text{ mol L}^{-1}$

$$\text{new } [\text{NH}_4^+] \sim 0.1 + 0.093 = 0.193$$

$$\text{pH} = \text{pK}_a + \log \frac{0.1}{0.193} = 9.24 - 0.29 = 8.95$$